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On the Merit of Observations Beyond the Cluster Core

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Abstract. I discuss recent seminal work on the LARCS dataset: a panoramic study of rich clusters of galaxies at $z \sim 0.12$. The importance of observing beyond the cluster core is illustrated by exploiting these data to examine colour gradients across the clusters.

1. Introduction

The Las Campanas / AAT Rich Cluster Survey (LARCS; O'Hely et al. 1998; Pimbblet et al. 2001a; 2001b; Pimbblet 2001) is a long-term project to study a statistically-reliable sample of 21 of the most luminous X-ray clusters at intermediate redshifts ($z = 0.07$–0.16) in the southern hemisphere. The photometric imaging of these clusters comprises homogeneous, two degree wide B and R band observations taken at Las Campanas Observatory. These data permit tracing of photometric variations in cluster members out to large radii (typically ~ 12 Mpc at $z \sim 0.12$). Galaxies selected from these data are being observed in an on-going spectroscopic follow-up (Pimbblet 2001) with the 2dF spectrograph on the Anglo-Australian Telescope.

2. Beyond the Core

Recently, theoretical and observational attention has been turned to the properties of galaxies beyond the cluster core, existing betwixt the infall regions and the virial radius of clusters (e.g. Balogh, Navarro, & Morris 2000; Pimbblet et al. 2001b; Kodama et al. 2001). This region is crucial for understanding the evolution of the galaxy population in clusters as they grow through the accretion of field galaxies at $z \leq 1$, and hence to answer important questions regarding the origin of such basic correlations as the morphology-density relation seen at the present day (Dressler 1980). At intermediate redshift most field galaxies are actively forming stars. Yet, as these galaxies fall into clusters, their star formation rate declines, eventually to zero (Poggianti et al. 1999). The first clear demonstration of this transformation is reported by Abraham et al. (1996) who show that the reddest spectroscopically-confirmed cluster members, those lying on the colour-magnitude relation (CMR), in the $z = 0.23$ cluster Abell 2390, get progressively bluer as a function of cluster radius out to ~ 5 Mpc.

Pimbblet et al. (2001b) analyze a sample of eleven LARCS clusters and combine these to trace the CMR from the dense cluster core out to the low-density field. They report that a small blueward shift of $d(B-R)/dr = -0.022\pm$

0.004 (or, equivalently in terms of local-density: $d(B-R)/dlog_{10}(\Sigma) = -0.076 \pm 0.009$) is present in the colours of the peak of the CMR, out to $\sim$ 6 Mpc; equivalent to $\Delta(B-R) \sim 0.1$.

A statistical background correction technique, however, is used by Pimbblet et al. (2001b) to define cluster membership, therefore the CMR radial blueing signal may be contaminated by background galaxies. Spectroscopic observations of the LARCS galaxies (Pimbblet 2001) are yielding membership information for individual galaxies needed to improve the signal-to-noise in the CMR at large radii where this contamination becomes important. Present results show a spectroscopically-confirmed blueward shift in the CMR's peak colour of $d(B-R)/dr = -0.017 \pm 0.005$ which is consistent with the statistically-defined membership result. Pimbblet et al. (2001b) suggest that these trends most likely reflect differences in the luminosity-weighted ages of the galaxies in different environments. If interpreted purely as a difference in ages then the gradient observed within LARCS suggests that the luminosity-weighted ages of the dominant galaxy population within the CMR at 6 Mpc from the cluster core are some 3 Gyrs younger than those residing in the core.

3. Summary

To conclude, wide-field observations are paramount to the understanding of cluster formation and evolution and to trace radial variations in the cluster population (i.e. the CMR is readily observed to beyond 8 Mpc in many LARCS clusters; Pimbblet 2001). Although some recent work on a single high redshift cluster has already been undertaken by Kodama et al. (2001), much further work (photometric and spectroscopic) is urgently required to comparatively examine radial trends within a larger, well-defined sample of higher redshift clusters. Such observations would allow the testing of the prediction that these trends will be more strongly pronounced at higher redshifts (Pimbblet et al. 2001b).

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